TWO OHIO SUBTERRANEAN ASCOMYCETES AND THEIR ASCOMYCETOUS PARASITES.*

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The genus Cordyceps is of considerable interest to mycologists and to other naturalists. Most of the species are parasites of insects, the fruiting bodies developing on the larval or pupal stages, and in some species on the adult stage, of the insect (5, 6). The species most commonly found is *C. militaris* (L.) Link which occurs on buried pupæ and larvæ. The writers, and others, have collected it in Ohio several times in recent years. The fruiting body is a slender, firm but fleshy structure, one to two inches tall and orange-yellow in color. The upper portion is covered with pimple-like papillæ which mark the position of the embedded perithecia containing the numerous asci, each with its eight slender ascospores. The genus is placed in the pyrenomycetous order, Hypocreales.

There are two species of Cordyceps, however, which are parasitic on certain fungi belonging to the genus Elaphomyces. The species of Elaphomyces are all subterranean. The mycelium of some of them forms mycorrhizas with the roots of coniferous trees, species of pine being most frequently mentioned. Dodge (1), in his recent monograph, lists 24 known species, of which he reports eight to occur in America with an additional doubtful record. Only two of these, *E. muricatus* Fr. (from Michigan) and *E. variegatus* Vitt. (from Iowa), have been reported from the north central states.

The fruiting body of the species of Elaphomyces is more or less globose and covered with a relatively thick rind of three distinct layers: The *crust* or outer layer, the *cortex* or middle layer and the *peridium* or inner layer. The spores are borne in asci which occur in scattered groups throughout the central portion of the fruiting body. The asci disappear after the spores are formed and the mature fructification is more or less completely filled with a brown powdery mass of spores. This genus is included in the order Aspergillales of the Plectomycetæ.

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While collecting fungi in the deep ravine below Old Man's Cave in Hocking County, Ohio, on August 15, 1925, the writers found a specimen of clavate Cordyceps. Upon removing it from the soil, it was discovered to arise from a globose subterranean fungus having much the appearance of a golf ball except as to color. This was later determined as *Elaphomyces variegatus* Vitt. The next day about a dozen other specimens of this species were found in the same ravine on a rock ledge covered with well-decayed leaf mold. Other collections have been made since as recorded below.

On October 9, 1926, a capitate Cordyceps was collected near Sugar Grove, Fairfield County, Ohio. This specimen developed from the buried fruiting body of another species of Elaphomyces which was later determined as *E. anthracinus* Vitt. After taking field notes on these collections, the specimens were preserved in 7% formaldehyde, and later studied more fully in the laboratory.

These collections are of particular interest because, so far as we have been able to learn, none of the species has been previously reported for this region. *E. anthracinus* has been reported in America only from Tennessee and North Carolina; *E. variegatus* is here recorded from the Ohio Valley for the first time, while neither of the species of Cordyceps has hitherto been reported west of the Alleghenies. The ranges of all four of the species discussed is therefore considerably extended.

Elaphomyces variegatus Vitt.

The fruiting body is subterranean; globose, subglobose or somewhat flattened; 1-3 cm. in diameter; yellowish-brown, and covered with warts of the same color. The warts are about as broad as high and rounded at the tips. Their bases are mostly pentagonal or hexagonal, although the smaller ones are often triangular. The peridium is quite thick and firm, and brownish-rose in color. In sections of the peridium there are reddish-brown reticulations plainly to be seen throughout its thickness. No asci were found in any of the specimens examined, but the characteristic dark-brown ascospores were quite abundant, filling the whole interior. According to our measurements the spores are 18-21 microns in diameter.

Our specimens were found in well-decayed leaf mold, two to four inches beneath the surface, in a damp ravine at Old Man's Cave, Hocking County, Ohio; Stover and Johnson, August 15, 16, 1925; Johnson and Dobbins, August 29, 1926; Stover, Johnson and Humphrey, September 10, 1927.

This was at first assumed to be *E. cervinus* (L.) Schlecht., probably the most common species of the genus, and frequently referred to in the literature as *E. granulatus* Fr. After microscopic examination, however, our specimens were determined to be *E. variegatus* Vitt. as interpreted by Dodge (1). In both species, the "crust" or outer mycelial layer, is readily separated and therefore not usually seen. The peridium, or inner layer of the rind, is markedly different in the two species, however. In *E. variegatus*, it is described as being grayish-rose to chestnut in color and "marbled with reddish-brown reticulations." In *E. cervinus* the peridium is white and without reticulations. The spores of the latter species are considerably larger, measuring 26-30 microns in diameter. Our specimens agree with Dodge's description of *E. variegatus* in all essential respects. He does not mention the triangular bases of the smaller warts and we were not able to demonstrate a "yellow gel" surrounding the warts, perhaps on account of the preservation of the specimens in formaldehyde.

According to Dodge, *E. variegatus* has previously been collected in southern Europe, New England, Florida and Iowa. Lewton-Brain (3) studied material collected in Scotland. He, as well as others, states that it forms a mycorrhiza with the roots of pine and other conifers. No observations were made by the writers on this point, but hemlock trees were growing near the place of collection and it is quite possible that a mycorrhizal relation had been established between the mycelium of the fungus and the roots of the hemlock. The yew (*Taxus canadensis* Marsh) also occurs in that part of the ravine, while two species of Pinus grow on the hills just above the ravine.

Most of these specimens were parasitized by *Cordyceps parasitica* (Willd.) Seaver which is described below. In fact the latter fungus was seen first and the Elaphomyces was found only upon removing the Cordyceps from the soil. A few of the fruiting bodies had no parasites attached.

Elaphomyces anthracinus Vitt.

The fruiting body is subterranean, globose, about 1.3 cm. in diameter and dark brown to black in color. The outer layer, the crust, is readily separated from the hard, fragile, carbonaceous cortex. The peridium, or inner layer of the rind is thick, white, with a dark line near the middle, and cottony in texture. The interior is filled with the dark spore-bearing portion. No asci were found in our specimen. The spores

are brown to dark brown, globose, 15-20 microns in diameter according to our measurements. The outer surface is often thickly studded with fine points or prickles.

This species was collected by the writers at Sugar Grove, Fairfield County, Ohio, October 9, 1926. The single plant was found in a damp ravine, about two inches beneath the surface of well-decayed leaf mold. There are hemlock trees in the immediate vicinity and pines on the hill just above the ravine. The specimen agrees very well with Dodge's (1) description of *E. anthracinus*. Our plant was parasitized by *Cordyceps agariciformia* (Bolt.) Seaver, which is described below.

Although apparently fairly common in central and southern Europe, this species has been previously reported in this country only from Tennessee and North Carolina, according to Dodge (l. c.)

Cordyceps parasitica (Willd.) Seaver.

The fruiting body or stroma consists of a cylindrical stalk and a club-shaped fertile portion or head. The whole fruiting body becomes very dark brown or black. In some of our specimens the stalk or its base was deep yellow or golden-orange when collected but became black later. The head is somewhat broader than the stalk; usually compressed laterally, but sometimes nearly circular in cross section; when compressed, usually narrowly elliptical in outline; rounded at the apex and narrowed gradually toward the stalk; 1.5-2.5 cm. high and 3-9 mm. across; clearly differentiated from the stalk, and covered with numerous small papillæ which mark the position of the ostioles of the embedded perithecia.

The stalk is slender, usually cylindrical, nearly smooth or sometimes longitudinally striate under the lens; 2.5-9 cm. long and 2-4 mm. in diameter; apparently branching at the base into a several root-like mycelial strands or rhizomorphs which extend through the soil and are attached to fruiting bodies of *Elaphamyces variegatus* Vitt.

The ascospores are filiform and nearly as long as the slender ascus which contains them; many-septate, at maturity breaking up into segments only slightly longer than broad.

Our plants were parasitic on fruiting bodies of *Elaphomyces variegatus* Vitt. in a damp ravine at Old Man's Cave, Hocking County, Ohio: Stover and Johnson, August 15, 16, 1925; Johnson and Dobbins, August 29, 1926; Stover, Johnson and Humphrey, September 10, 1927; Stover and Miller, October 12, 1929.

This fungus occurs in Europe and, as recorded by Seaver (5, 6), its American distribution is "Ontario to Rhode Island and Virginia."

C. parasitica is quite similar in appearance, size, shape and color to certain species of the Geoglossaceæ, but is readily distinguishable on account of the pimple-like papillae covering the upper portion of the fruiting body.

This species and the following are the only members of the genus Cordyceps known to occur as parasites on fungous fruiting bodies. Lloyd (4) points out that these two species differ not only in the shape of the fruiting body (stroma) but also in their method of attachment to their hosts, and in the character of the ascospores. In our specimens of *C. parasitica* the mycelial strands are a prominent feature. They are much branched and sometimes several centimeters long. When fresh they were deep yellow but became very dark brown or black after preservation. This fact, with other observations on the color, recorded above, leads us to believe that the whole fruiting body is probably yellow to orange when young.

Cordyceps agariciformia (Bolt.) Seaver.

The fruiting body or stroma in our specimen is 7 cm. tall and consists of a sterile stalk and a cap-like head or fertile portion. The ovoid head was about 1 cm. in diameter, yellowish below to brown and blackish above and somewhat shining when fresh. The entire surface of the head is covered with numerous papillæ which contain the ostioles of the embedded perithecia. The stalk was yellow when fresh but the whole plant is black since being preserved. The stalk is 5 mm. in diameter at the base, tapering somewhat toward the apex, smooth below and somewhat scaly above. The asci are slender and cylindrical; the ascospores are filiform, nearly as long as the ascus and are said to break up into rather long segments when mature.

This species was collected by the writers October 9, 1926, at Sugar Grove, Fairfield County, Ohio. The single specimen found was parasitic on *Elaphomyces anthracinus* Vitt., developing directly upon it without any mycelial strands such as those found in *C. parasitica* (Willd.) Seaver. It will be noted that the stalk and lower part of the head were yellow or yellowish when collected and later became black. It seems probable that the head, although black in our specimen when collected, is at first some shade of yellow. Seaver (5, 6) however, states that it is reddish-brown. The distribution, as recorded by

Seaver (l. c.) is "Maine to Ontario and Florida." Lloyd (4) and Hard (2) discuss and illustrate the fungus under the name *C. capitata* (Holmsk.) Link, formerly often used.

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